20.04.2025

Navigating Legal Landscape of Autonomous Vehicles: Technology, Artificial Intelligence and Cyberlaw: Regulating the Digital Future (2025)

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ABSTRACT

The emergence of autonomous vehicles (AVs) has raised complex legal issues that require careful consideration across multiple dimensions. This paper examines the legal landscape surrounding AVs, focusing on the allocation of liability among manufacturers, programmers, and drivers in the event of accidents. The study examines existing international legal frameworks governing AVs, highlighting both the similarities and disparities across jurisdictions and their implications for global regulatory alignment. Moreover, the paper investigates the specific challenges faced by India and other developing countries in integrating AV technology, such as infrastructure limitations, regulatory hurdles, and socio-economic factors that influence public acceptance and policy development. Through a case study, the paper also offers practical insights into the successes and difficulties encountered by countries in implementing AV-related policies. The research aims to provide a comprehensive overview of the legal complexities while forming regulations relating to autonomous vehicles and proposes actionable recommendations.

INDEX TERMS

Autonomous Vehicles, Artificial Intelligence, Comparative Negligence, Machine learning, No fault insurance, Product Liability, Sensor Integration (LiDAR, radar)

INTRODUCTION

The swift advancement of autonomous vehicle (AV) technology is revolutionizing the world, with the potential to significantly enhance mobility, improve safety, and reduce environmental burdens. AVs promise to alleviate traffic congestion, reduce accidents caused by human error, and lower emissions by promoting better driving behavior. However, the widespread adoption of AVs raises complex legal and regulatory challenges that must be highlighted to ensure their

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safe integration into existing transportation systems. As with any disruptive technology, the legal landscape surrounding AVs must evolve to address emerging questions about liability, accountability, and governance in the face of accidents and system failures. The legal frameworks that have traditionally governed road traffic and accidents may not be fully equipped to handle the complexities of AV technology. While autonomous vehicles offer the potential to reduce the high number of traffic-related accidents, such as those caused by human error, they also introduce new forms of risk, particularly in the areas of cybersecurity, privacy, and system failure. In countries like Indonesia, where road safety is a significant issue with human error accounting for over 60% of accidents, the introduction of AVs could represent a significant opportunity to reduce traffic fatalities and improve overall road safety. However, the challenges surrounding infrastructure, cybersecurity, and the establishment of clear liability protocols are hurdles that must be overcome before AVs can be addressed on a large scale.

To navigate the legal landscape of AVs, it is essential to understand how existing liability and accountability frameworks can be adapted to address new risks posed by autonomous systems. This paper examines the adequacy of current legal structures and explores whether they are capable of assigning responsibility in the event of AV-related accidents. By drawing on case studies, from different regions and navigating changes in everyday lives bought upon by adoption of such underdeveloped technology.

RESEARCH QUESTIONS

1. How has the legal framework for autonomous vehicles evolved alongside technological advancements?
2. What are the potential legal and regulatory challenges in the widespread adoption of autonomous vehicles?
3. How is regulation and implementation of autonomous vehicles approached globally, and what lessons can be learned from their policies?
4. Are existing legal and regulatory frameworks sufficient to address the complexities of autonomous vehicle deployment, or do they require modifications?
5. What changes are required in current legal frameworks to ensure safety, liability clarity, and ethical considerations in the adoption of autonomous vehicles?

RESEARCH OBJECTIVE

1. To analyze the distribution of liability among manufacturers, programmers, and drivers in the context of autonomous vehicle accidents
2. To evaluate the international legal frameworks governing autonomous vehicles and identify gaps and inconsistencies.
3. To investigate the challenges faced by India and other developing nations in implementing autonomous vehicle technology.

HYPOTHESIS

Null Hypothesis (H_0): Existing liability frameworks are adequate for addressing accidents involving autonomous vehicles, effectively assigning responsibility among manufacturers, drivers, and programmers.

Alternative Hypothesis (H_1): Existing liability frameworks are inadequate for addressing accidents involving autonomous vehicles, leading to challenges in assigning responsibility among manufacturers, drivers, and programmers.

HYPOTHESIS-BASED LITERATURE REVIEW

1. *Brodsky, "Autonomous Vehicle Regulation: How an Uncertain Legal Landscape May Hit the Brakes on Self-Driving Cars" (2016)[3]:* The difficulties presented by the disjointed legal environment governing autonomous vehicles (AVs) in the US are discussed by Brodsky. The study highlights how autonomous vehicles (AVs) have the potential to improve traffic flow, lessen environmental impact, and prevent traffic accidents brought on by human mistakes. State-to-state regulatory disparities, however, are a major obstacle to the adoption of AV, according to Brodsky. Manufacturers and developers face uncertainty due to the current patchwork of state legislation, which could hinder innovation. To expedite AV oversight, the author advocates for the creation of comprehensive federal regulations or a specialized agency. A method like this would address liability issues, product safety, and cross-border operations while harmonizing state and federal regulations. Brodsky concludes that effective AV integration into society requires deliberate governmental involvement.

[3] Brodsky, J. S. (2016). Autonomous Vehicle Regulation: How an Uncertain Legal Landscape May Hit the Brakes On Self-Driving Cars

2. *Seidenberg, "Behind the Wheel: Who's to Blame When Self-Driving Cars Crash?" (2017)[4]:* Seidenberg (2017) concentrates on the intricate legal issues surrounding culpability in accidents involving AVs. The study examines the difficulties in determining who is at fault—human operators or autonomous vehicles—using the 2016 Tesla Autopilot accident as its main example. The accident brought to light the shortcomings of the laws and regulations controlling modern AV technology. The National Highway Traffic Safety Administration (NHTSA) stressed the need of human drivers being alert even if it did not discover any flaws in Tesla's Autopilot. Seidenberg points out that the legal requirement for human supervision may become problematic as AVs grow increasingly independent. The significance of updating liability rules to take into account the transfer of control from humans to machines is emphasized in the study. It also presents moral questions regarding who should be held accountable—manufacturers, programmers, or operators.

3. *Li, "The Dangers of Digi-things" (2018)[5]:* Li (2018) investigates the wider ramifications of incorporating automation, robots, and artificial intelligence (AI) into society, including driverless cars. Concerns regarding cybersecurity and the possible weaknesses of AVs as a component of the larger "Internet of Things" are highlighted in the article. Although AVs provide many advantages, such as increased efficiency and safety, Li notes that current regulations are inadequate to handle the particular hazards associated with autonomous systems. These dangers include system failures, data leaks, and hackers. Li contends that the intricate relationships between AV systems, their surroundings, and human operators cannot be adequately regulated by conventional legal frameworks, which were created for human-driven cars. In order to handle the ever-changing issues presented by autonomous technologies, the paper advocates for the creation of flexible legal standards.

[4] Seidenberg, S. (2017). Behind the Wheel: Who's to blame when self-driving cars crash? ABA Journal, 103(7), 18–19

[5] LI, V. (2018). The Dangers of Digi-things: WRITING THE LAWS WHEN DRIVERLESS CARS (OR OTHER COMPUTERIZED PRODUCTS) TAKE A WRONG TURN. ABA Journal, 104(3), 38–47

4. *Nyholm and Smids, "The Ethics of Accident-Algorithms for Self-Driving Cars" (2016)[6]:* The ethical programming issues surrounding autonomous vehicles (AVs), specifically the creation of accident algorithms for situations involving inevitable collisions, are examined by Nyholm and Smids (2016). The authors argue that the philosophical trolley dilemma oversimplifies the complexity of real-world decision-making, and they critically assess the popular connection between these algorithms and the problem. Three significant distinctions are noted in the paper: Unlike the trolley problem, which assumes certainty, real-world scenarios involve uncertainty and probabilistic outcomes; (2) manufacturers, programmers, and regulators share moral and legal responsibility in AV programming; and (3) programming decisions are made by groups of stakeholders rather than by individuals. Nyholm and Smids advocate for ethical frameworks that take these difficulties into consideration, placing a strong emphasis on openness and public participation in the creation of AV decision-making procedures.

5. *Gless, Silverman, and Weigend, "If Robots Cause Harm, Who is to Blame? Self-Driving Cars and Criminal Liability" (2016[7])*: Gless, Silverman, and Weigend (2016) address criminal culpability about autonomous vehicles (AVs), concentrating on situations in which robots inflict harm. The study makes the case that current criminal law frameworks find it difficult to assign blame when dealing with autonomous systems. Because AVs are intelligent agents that rely on intricate algorithms and machine learning, their behavior is sometimes unpredictable. The authors suggest restricting operators' criminal culpability to instances of egregious carelessness in which appropriate precautions were not taken to reduce hazards. In order to handle the particular difficulties posed by AV-related accidents, they also investigate alternate responsibility models, such as group compensation funds or no-fault insurance plans. The study concludes that to promote AV use while maintaining accountability, a balanced strategy is required.

[6] Nyholm, S., & Smids, J. (2016). The ethics of accident-algorithms for self-driving cars: An applied trolley problem? Ethical theory and moral practice, 19(5), 1275-1289.

[7] Gless, S., Silverman, E., & Weigend, T. (2016). If robots cause harm, who is to blame? Self-driving cars and criminal liability. New Criminal Law Review, 19(3), 412-436.

6. *Marta Bo's study, "Are Programmers in or 'out of' Control?[8]"* examines the criminal liability of programmers who work on autonomous weapons systems (AWS) and autonomous vehicles (AVs). It investigates if these programmers are accountable for crimes committed as a result of these technologies' operation. The study emphasizes the crucial role that programmers play, pointing out that their impact starts during the design stage and continues throughout the use of the technology, particularly in situations when hazards are predictable. The paper ties programmers' actions to legal accountability through assessments of causality and liability by putting forth the idea of "meaningful human control," particularly in situations of carelessness or reckless design.

RESEARCH METHODOLOGY

This study is based on secondary data, analysis of relevant data of present. Navigating Legal Landscape of Autonomous Vehicles. The study is done with the help of secondary data. Reliability is directly proportional to these data.

DISCUSSION

Autonomous vehicles (AVs) are progressively transforming the landscape of personal and public transportation, with their global presence and market value on a notable upward trajectory. In 2019, approximately 31 million vehicles equipped with some levels of automation were operational worldwide, a figure projected to exceed 54 million by 2024[9]. Correspondingly, the global autonomous car market, valued at over $24 billion in 2021, is anticipated to nearly triple to around $62 billion by 2026.

The Society of Automotive Engineers (SAE) has established a six-level classification system to delineate the degrees of vehicle automation, ranging from Level 0 (no automation) to Level 5 (full automation)[10]. Despite significant advancements, achieving fully autonomous (Level 5) vehicles remains a complex challenge, primarily due to technological limitations and safety

8 Bo, M. (2022). Are Programmers In or'Out of'Control? The Individual Criminal Responsibility of Programmers of Autonomous Weapons and Self-driving Cars.
9 Global AV usage in 2019 and projections for 2024
International Transport Forum. (2020). Safe and sustainable transport: Automation level trends. OECD Publishing.
10 SAE International. (2018). Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles (J3016_201806).

considerations. Consequently, current market trends indicate that by 2025, nearly 60% of new cars sold globally will feature Level 2 autonomy, characterized by partial automation where the driver must remain engaged. By 2030, while Level 2 vehicles are expected to continue dominating the market, Levels 3 and 4—which offer conditional and high automation, respectively—are projected to constitute about 8% of new car sales.

The pursuit of autonomous vehicle technology has attracted a diverse range of stakeholders, which includes: established automotive manufacturers, technology firms, and scalable startups. Major industry players such as General Motors, Toyota, Nissan, Volkswagen, Ford, and Tesla have made significant investments in this domain. Strategic collaborations and acquisitions have become commonplace as companies seek to enhance their technological capabilities and talent pools. Notable examples include General Motors' acquisition of the startup Cruise in 2016 and Toyota's purchase of Lyft's autonomous vehicle division in 2021. Additionally, startups like Argo AI have secured substantial funding from industry giants Ford and Volkswagen, underscoring the collaborative efforts driving the sector forward.

Based on consumer interest in Autonomous Driving (AD) features, and commercial solutions available on the market today, Advanced Driver Assistance Systems and AD could generate between $300 billion and $400 billion in the passenger car market by 2035." This growth is driven by increasing consumer demand for AD features and the anticipated widespread adoption of vehicles equipped with Level 2+ to Level 4 automation capabilities[11].

As autonomous vehicles (AVs) become a vital part of modern transportation systems, determining liability in the event of an AV-related accident has emerged as a critical challenge. Unlike traditional vehicles, where human error is the primary cause of accidents, AVs operate through a complex interplay of hardware, software, and artificial intelligence. This shift in dynamics has led to the broad classification of liability into three primary domains: programmers, who design the software controlling the vehicle; manufacturers, responsible for the hardware, implementation of design, and overall system integration; and drivers, who may still have partial control or supervisory duties in certain scenarios. Understanding the nuances of each category is essential for developing a comprehensive framework to address liability in AV-related incidents.

[11] McKinsey & Company. (2023, January 6). Autonomous driving's future: Convenient and connected.

A. MANUFACTURERS LIABILITY

Manufacturers of autonomous vehicles (AVs) carry significant liability for accidents caused by their products, particularly as AVs shift the responsibility for safe operation from human drivers to the vehicle itself. This liability is multifaceted, encompassing defective software, hardware integration, and the overall system design. Below, key aspects of manufacturers' liability in AV-related accidents are analyzed.

The liability of manufacturers in AV-related accidents underscores the paradigm shift in transportation. As the vehicle assumes tasks traditionally performed by drivers, manufacturers must ensure the safety and reliability of every aspect of their product.

1. *Software Defects*

The dependency on software to perform driving tasks introduces unique challenges. AVs operate using advanced algorithms, machine learning models, and real-time data processing to navigate and make decisions on the road. Suppose a software defect—such as errors in object detection, misclassification of hazards, or poor decision-making logic—leads to an accident. In that case, the manufacturer may be held strictly liable under product liability principles. The article argues for extending liability to manufacturers, ensuring accountability for defective software that compromises safety[12]. Strict liability would ensure manufacturers internalize the costs of software-related failures, providing stronger incentives for rigorous testing and quality assurance. There is requirement for a strict liability regime for manufacturers to address the unique risks posed by AVs. This approach holds manufacturers accountable for injuries and damages caused by defects, regardless of whether negligence can be proven. Such a framework ensures that the costs of accidents are borne by the parties best positioned to prevent them.

2. *Integration*

Manufacturers are responsible for integrating hardware components like LiDAR, radar, and sensors with the AV's software systems. Defects in integration, such as incorrect calibration of sensors or miscommunication between components, can result in accidents. For instance, if LiDAR data misrepresents the distance of an obstacle and the code fails to adjust the vehicle's path accordingly, liability falls on the manufacturer. Courts may evaluate whether

[12] Sever, T., & Contissa, G. (2024). Automated driving regulations–where are we now?. *Transportation research interdisciplinary perspectives*, *24*, 101033.

manufacturers adhered to industry standards and performed adequate system-wide testing to ensure interoperability.

3. *Predictable Misuse*

Even if AVs meet technical specifications, their design must account for predictable misuse and limitations in real-world environments. The manufacturer could be held liable if a vehicle's design fails to anticipate reasonably foreseeable challenges, such as extreme weather conditions affecting sensor performance or atypical driving environments. The "failure to warn" doctrine may also apply if manufacturers do not adequately inform consumers about the risks of the AV system.

4. *Cybersecurity*

Manufacturers must ensure that AVs are protected against cybersecurity threats. Manufacturers can be held accountable if they fail to implement adequate cybersecurity measures, such as secure firmware updates and robust encryption protocols, to prevent accidents.

5. *Economic and Legal Implications*

Strict liability may lead to increased litigation and higher insurance premiums for manufacturers. Smaller companies could face challenges entering the market due to the high costs of compliance and potential lawsuits. However, these measures would promote safety and innovation, as manufacturers would invest more in preemptive safety measures and robust testing.

B. PROGRAMMERS

Programmers play an important role in the development of AV systems, their decisions directly influence the vehicle's behavior through algorithm design and system functionality. When AV-related accidents occur, determining their liability depends on whether their actions or omissions can be causally linked to the incident. For liability to arise, the programmer's conduct must contribute to the harm, the risks[13] must be foreseeable, and appropriate safeguards should have been implemented to mitigate potential dangers.

A primary area of concern is algorithm and data-related risks. Errors in algorithms, like object recognition or navigation systems, may lead to accidents, especially if programmers fail to

[13] Gless, S. & Whalen-Bridge, H. (eds.), Human-Robot Interaction in Law and its Narratives: Legal Blame, Criminal Law, and Procedure, Cambridge University Press, 2022

embed precise and reliable coding. For instance, an incident where an AV misidentifies a pedestrian due to inadequate programming could point to negligence. Moreover, the reliance on machine learning introduces additional complexities. Algorithms trained through supervised and unsupervised learning are dependent on the quality and labeling of the data. Inaccurate or biased data can lead to system failures, raising questions about whether the programmer should have anticipated such faults and implemented safeguards. Liability is influenced by the distribution of control between programmers and users. Many AV manufacturers believe in shifting responsibility to users, arguing that oversight during driving could prevent accidents. However, human-machine interaction phenomena, such as automation bias—where users overly rely on the AV system—reduce the effectiveness of such arguments. In these cases, the programmer's responsibility to design an intuitive and fail-safe interface becomes critical. Failures in interface design that impair the user's ability to take corrective action could result in the programmer sharing liability.

The complexity of AV systems also introduces risks outside a programmer's control, such as hacking or external environmental factors. For example, incidents caused by adversarial attack like manipulated traffic signs that confuse an AV's sensors may fall outside the programmer's foreseeability. In such scenarios, determining liability requires assessing whether the programmer reasonably anticipated such vulnerabilities and designed the system to resist them. Programmer liability in AV-related accidents is determined by their control over the system's behavior and their ability to foresee and lower risks. This approach seeks to balance innovation with the need for accountability, protecting public safety in an era of increasing automation.

C. DRIVERS

The liability of human drivers in autonomous vehicle (AV) accidents is a multifaceted issue determined by the level of automation and specific circumstances of the incident. At lower levels of automation (SAE levels 0–4), drivers retain significant control over the vehicle, making their role in preventing accidents central. For instance, if an AV operating in level 3 requires a driver to take control and they fail to respond on time, they may be held liable for negligence. However, at levels 4 and 5, where the vehicle is primarily or fully autonomous, the scope of driver liability diminishes significantly, raising questions about the operator's legal and moral responsibilities.

Human drivers can mount several defenses to shift liability toward manufacturers, programmers, or other parties involved in the AV ecosystem. For example, in scenarios where an accident results from a product defect, such as a malfunctioning sensor or software failure, drivers can argue that the root cause was beyond their control. Comparative negligence is another defense, where the driver demonstrates that their actions were less contributory to the accident compared to failures in the AV's design or operation. Additionally, drivers can challenge liability by pointing to insufficient or unclear manufacturer warnings about the vehicle's limitations, particularly in cases where they were unaware of necessary interventions during autonomous operation.

Another key area is the failure of manufacturers to ensure software updates or the vulnerability of AV systems to hacking, which can protect the driver. In such cases, drivers may argue that the accident was a result of systemic issues that fall under the purview of the manufacturer or service provider. This defense becomes more relevant in higher levels of automation, where the AV's decision-making is independent of human input. Regulatory bodies must establish clear guidelines for attributing fault and ensure that liability is equitably distributed among drivers, manufacturers, and other stakeholders. This would prevent unjust liability on individual drivers and promote accountability across the entire AV development and operational chain.

I. CASE STUDY

a. *Increase in Product Litigation*

Even though the determination of liability in uncertain globally, Muhammad Uzair in his 2021 study demonstrates two primary approaches to managing the rise in product liability claims: product liability deemphasized and product liability further sharpened, each reflecting contradictory perspectives on how responsibility should be distributed among stakeholders, i.e., manufacturers and drivers.

The "product liability deemphasised" approach proposes shifting the burden of liability partially onto consumers, even in cases of product failure. Under this model, manufacturers would be excluded from liability for damages covered by a third party. To balance this exemption, manufacturers would contribute to third-party liability insurance for each vehicle. This approach, however, raises ethical concerns as it potentially protects manufacturers from accountability while placing undue risk on consumers. It also assumes consumers have the expertise to assess the safety of complex AV systems, which may not be realistic. However, the reputational risk from recalls and accident records would still incentivize manufacturers to prioritize safety.

On the other hand, the "product liability further sharpened" approach focuses on holding manufacturers strictly liable for injuries and damages caused by product failures. While this approach aligns with consumer protection principles, it imposes a higher burden on claimants to prove defects in the product. This can be challenging, since determining the root cause of an accident (e.g., hardware malfunction, software failure, or external factors) often requires complex technical analysis and substantial resources.

Figure 1, "the accident cost is represented by the light blue slice in the background, and this expense is expected to decrease in AVs in the future due to the increased safety. The dark blue slice in the background pie represents product liability (percent of expenses occurring due to product liability), and it will increase in AVs in the future. Accident magnitude (number of accidents) defines those accidents in which a vehicle component breaks or malfunctions. The accident magnitude effect is shown by light red slices in the foreground pie which shows that the number of accidents will decrease in the future in AVs due to improved safety. The darker slices (red) in the foreground pie (smaller pie) represent product failure, which shows that product failure will increase in the future and it will be the main contributor for AVs in future accidents."[14]

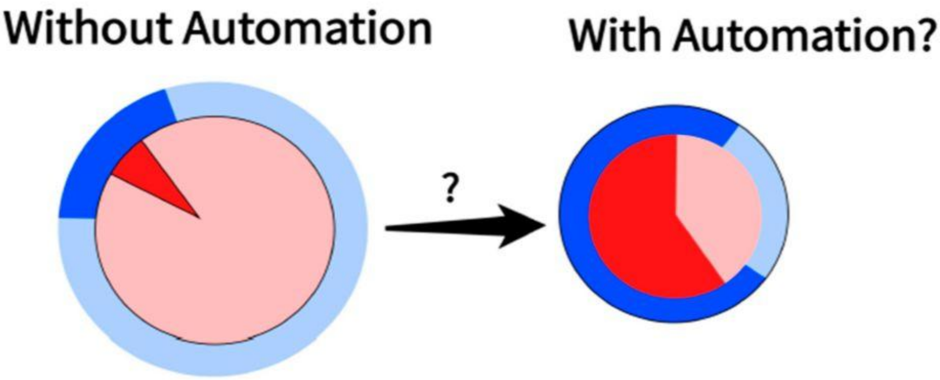

Figure 1

b. *Indonesia's Legal Landscape on Autonomous Vehicles*

Indonesia is in the early stages of exploring the implementation of autonomous vehicles. The Ministry of Transportation has initiated studies to assess the feasibility and implications of self-driving cars in the country. Minister Budi Karya Sumadi has called upon private firms and

[14] Bryant, W.S. Automated Driving and Product Liability, Michigan State Law Review, 2017. University of South Carolina-Law Library, USA

universities to engage in the development of AV technology, acknowledging both the potential benefits and the challenges, including regulatory frameworks and infrastructure development. [15]

Despite these initiatives, Indonesia currently lacks adequate regulations specifically addressing autonomous vehicles. Existing laws, such as the "Undang-Undang Lalu Lintas dan Angkutan Jalan" (UU LLAJ), do not adequately accommodate the nuances of AV technology. This regulatory gap raises concerns about liability in the event of accidents involving self-driving cars and underscores the need for updated legislation that considers the unique aspects of autonomous driving systems[16].

The Indonesian government's interest in incorporating AVs, notably in the creation of the new capital city in East Kalimantan, demonstrates a forward-thinking approach to smart city design. However, the lack of an acceptable legislative framework creates problems that must be overcome in order to ensure the safe and effective deployment of autonomous cars in Indonesia. To summarize, the global progress of autonomous vehicle technology needs a thorough evaluation of current legal frameworks to resolve regulatory discrepancies, liability complications, and ethical quandaries. The case of Indonesia demonstrates the significance of proactive legislation creation to adapt developing technologies, ensuring that their incorporation into society is both helpful and legal.

Implementing self-driving cars (AVs) in developing countries like India involves a complicated set of issues spanning infrastructure, technology, regulation, economics, and society.

II. LIABILITY FRAMEWORKS

a. International Regulatory Frameworks

United States of America

The National Highway Traffic Safety Administration (NHTSA) has formulated guidelines to oversee the testing and deployment of AVs, focusing on safety

[15] Uzair, M. (2021). Who is liable when a driverless car crashes?. *World Electric Vehicle Journal*, *12*(2), 62

[16] Nurliyana, C., Lestari, Y. D., Prasetio, E. A., & Belgiawan, P. F. (2023). Exploring drivers' interest in different levels of autonomous vehicles: Insights from Java Island, Indonesia. Transportation research interdisciplinary perspectives, 19, 100820.

assessments, data recording, and cybersecurity protocols. The NHTSA has introduced the Automated Driving System Safety, Transparency, and Evaluation Program (AV STEP), a voluntary framework facilitating the integration of driverless vehicles into the transportation ecosystem. State Regulations Divergent state-level laws have engendered a heterogeneous regulatory environment. For example, California mandates that entities obtain permits for AV testing on public thoroughfares and requires the disclosure of disengagement reports and collision data.

Recent Developments: The federal administration has proposed prohibitions on AVs incorporating software and hardware from certain foreign nations, citing national security concerns. The proposed regulations aim to restrict such technologies by specified future model years.

European Union

EU Legislation the European Union has adopted an integrated approach through instruments like the General Safety Regulation (GSR), which regulates the inclusion of advanced safety features in vehicles, encompassing intelligent speed assistance and event data recorders. Additionally, the EU is revising its Product Liability Directive to encompass digital products, thereby holding software providers and manufacturers accountable for defects leading to accidents. German legislation permits the operation of Level 4 AVs within designated areas, contingent upon adherence to stringent safety requirements. France regulations authorize AV testing on public roads under specific conditions, with initiatives underway to integrate AVs into public transportation systems.

United Kingdom

The Automated and Electric Vehicles Act,2018, establishes a framework addressing insurance and liability issues pertinent to AVs, ensuring speedy compensation for parties affected by AV-related incidents. The UK is currently developing a comprehensive regulatory schema to facilitate AV deployment by the mid-2020s.

III. CHALLENGES FACED BY INDIA AND OTHER DEVELOPING COUNTRIES

The road infrastructure in many underdeveloped countries is frequently insufficient for the deployment of AVs. In India, for instance, highways are usually packed and chaotic, demanding a high level of driving skill and agility. Autonomous vehicles must be able to navigate this complexity to function efficiently. Furthermore, many roads are in bad condition, with potholes and other hazards that can limit the use of AVs. The lack of a solid network of sensors and communication tools, both of which are required for autonomous vehicles to function properly, compounds the problem.

The adoption of AVs is strongly reliant on constant and high-speed internet access, which is sometimes unavailable in developing countries. Unstable power grids and inadequate internet connection can jeopardize the real-time data processing capabilities required for autonomous vehicle operations. Furthermore, integrating sophisticated technology into existing vehicle systems presents new obstacles, particularly in places with undeveloped technological infrastructure.

The legislative framework in developing countries is frequently complex and uneven, offering substantial hurdles to the development and deployment of autonomous cars. In India, for example, the regulatory landscape varies by state, making it challenging for corporations to create and test AVs. Furthermore, the judicial system can be slow and ineffective, which complicates the legal difficulties surrounding autonomous car technology.

The enormous expenses of creating and deploying autonomous cars pose substantial economic hurdles in underdeveloped countries. In India, the cost of creating and deploying AVs may be prohibitively expensive for customers, and greater maintenance and repair expenses compared to conventional vehicles may further discourage adoption. This economic obstacle is exacerbated by developing economies' low financial resources, making it harder to invest in critical infrastructure and technologies.

Public acceptability of autonomous vehicles is vital to their effective implementation. Skepticism about new technologies can be a barrier to adoption in underdeveloped countries. Concerns about job loss, particularly in the transportation industry, may also be a barrier to AV integration.

In India, the adoption of autonomous vehicles faces challenges, primarily due to socioeconomic factors and urban mobility patterns. The current penetration of private vehicles is limited, with "car and motorized two-wheeler (MTW) ownership per 1,000 persons" at 13 and 67, respectively, in 2012 (Mohan, 2016). Projections indicate that by 2030, car ownership will rise to 80 per 1,000 persons, still significantly lower than in high-income countries, where rates range from 500 to 800 per 1,000 persons (Mohan, 2016). Moreover, "low-income levels, wide availability of MTWs, and relatively low-cost para-transit facilities" shape Indian cities' reliance on non-motorized and shared mobility options, which account for 30%-60% of trips (Mohan, 2016).

The economics of Driverless vehicles in India also poses concerns. Available technologies such as LIDAR, critical for autonomous navigation, add substantial costs. At an estimated additional cost of ₹6,00,000 for production, basic driverless vehicles may sell for more than ₹12,00,000, making them accessible primarily to "households earning more than ₹22,75,000 per year," which constitute less than 5% of the population [17](Mohan, 2016). Consequently, DLV penetration in urban India by 2030 is projected to remain below 5%-10% (Mohan, 2016).

Safety remains a debated issue in DLV adoption. Even though autonomous systems promise to minimize human error, challenges persist, particularly in environments where vehicles interact with everyday traffic. As Mohan (2016) states, "During the transition period when conventional and self-driving vehicles would share the road, safety might actually worsen," especially in India's chaotic urban traffic conditions.

Despite these challenges, DLV technology holds promise for specific applications. Shared public transport services, last-mile connectivity, and delivery systems could benefit from the integration of autonomous systems, potentially offering "efficiencies greater than present rail-based grade-separated metro systems at a fraction of the cost" (Mohan, 2016). Furthermore, innovations in semi-autonomous vehicle platoons for urban transit could revolutionize city-wide mobility.

Autonomous vehicles (AVs) must be adopted in an organized manner that addresses responsibility, safety, legal frameworks, and public confidence. Based on Muhammad Uzair's study "Who Is Liable When a Driverless Car Crashes?", many practical recommendations emerge:

a) *<u>Education and awareness.</u>*
   Educating users about the capabilities and limits of AVs is critical for ensuring safe use. Similarly, legislators must stay up to date on technological changes in order to develop

[17] Mohan, D. (2016). Driverless vehicles and their future in India. *Economic and Political Weekly*, 106-113.

effective and realistic legislation. Proper education for all parties can help to eliminate unreasonable expectations and provide a safer environment for AV deployment.

b) *Formation of new regulatory bodies.*

Specialized regulatory bodies should oversee the entire lifecycle of AVs, including pre-market testing, approval processes, and post-sale monitoring. These agencies can impose rigorous safety standards and mandate the elimination of risks found during procedures.

c) *Improved Procedures for Testing*

To make sure AVs are capable of handling a variety of scenarios, new testing procedures must replicate real-world circumstances. Consumer confidence and dependability will increase if testing criteria are updated frequently to reflect new developments in technology.

d) *Models of Insurance and Compensation*

Liability issues can be made simpler by innovative insurance models like victim compensation funds or no-fault systems. To ensure that consumers are not overloaded by insurance complexity, manufacturers may, for example, incorporate liability coverage into the price of automobiles.

e) *International Uniform Laws*

One of the biggest problems is that different locations have different legislation. AV safety, licensing, and liability uniform international standards can reduce disparities and promote more seamless worldwide adoption.

f) *Including Frameworks for Ethics*

Transparency and accountability are necessary when addressing moral conundrums, such as choosing whose lives to prioritize in an emergency. With the help of frameworks that strike a balance between safety and social norms, developers must include ethical issues into their programming and design.

g) *Proactive and Dynamic Regulation*

As AV technology advances, regulations must also change. While promoting innovation, proactive revisions to the legal and liability frameworks will guarantee that AVs stay compliant.

LIMITATIONS OF THE STUDY

This study is based on secondary data and does not include primary survey results.

CONCLUSION

Determining who is at fault when a fully autonomous vehicle (level 5) runs without human assistance is one of the main problems. When an AV causes an accident, it might not be obvious who is at fault—the software developers who developed the vehicle's decision-making algorithms, the operator who may have entered data or controlled the system, or the manufacturer who created and constructed the vehicle. This ambiguity complicates liability and makes it challenging to allocate blame in a way that is both equitable and compliant with the law. For instance, should the software developer be held accountable for a coding fault or the manufacturer for a design flaw if an antivirus program malfunctions or is unable to correctly analyze a traffic scenario?

Who is accountable for the outcomes of decisions made by the AV when it is trained to make them (for example, when it must choose between two possible accidents)?
These issues are not sufficiently addressed by current liability legislation. Liability is still based on human behavior in many jurisdictions, and current insurance models and policies are not prepared to deal with the complexity of autonomous technology. For example, conventional insurance plans that place blame on a driver are not applicable in the event of an AI-powered car failure or accident. A potential legal gray area results from the absence of established responsibility frameworks for AVs, where manufacturers may be subject to significant legal risks and accident victims may find it difficult to pursue compensation.

In addition, although some legal systems are starting to investigate strict liability or no-fault insurance models to deal with these problems, these frameworks are still in their infancy and are not adequately adapted to the particularities of AV technology. In order to ensure that accident victims receive compensation and that manufacturers and other stakeholders are held accountable, it is becoming more and more crucial to establish strong legal frameworks that can allocate responsibility in a fair and equitable manner as AVs become more common.
Accountability for AV-related incidents raises serious concerns about cybersecurity and the accuracy of vehicle data in addition to liability issues. AVs rely significantly on communication and data transfer between sensors, infrastructure, and cars. If an accident occurs, it could be challenging to determine whether the reason was caused by a technical failure, cyberattack, or an issue with data processing.

As manufacturers could be unwilling to provide proprietary information or system vulnerabilities out of concern for potential legal ramifications or reputational harm, this adds even more complexity to legal frameworks.

It is evident from these difficulties that the current legal and accountability systems are inadequate to handle AV-related accidents. Because of the intricacy of autonomous systems, the involvement of several parties in the creation and operation of these vehicles, and the quickly changing technological environment, standard liability models are unable to offer definitive solutions. New legal frameworks and procedures that address the particular problems raised by autonomous vehicles, provide equitable responsibility, and safeguard the interests of both parties are desperately needed as AV technology develops.

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